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USING LIGHT EMITTING DIODES (LED) IN AIRCRAFT ANALOG INDICATORS--ETC(U)
FEB 79 J TOMASZEWICZ
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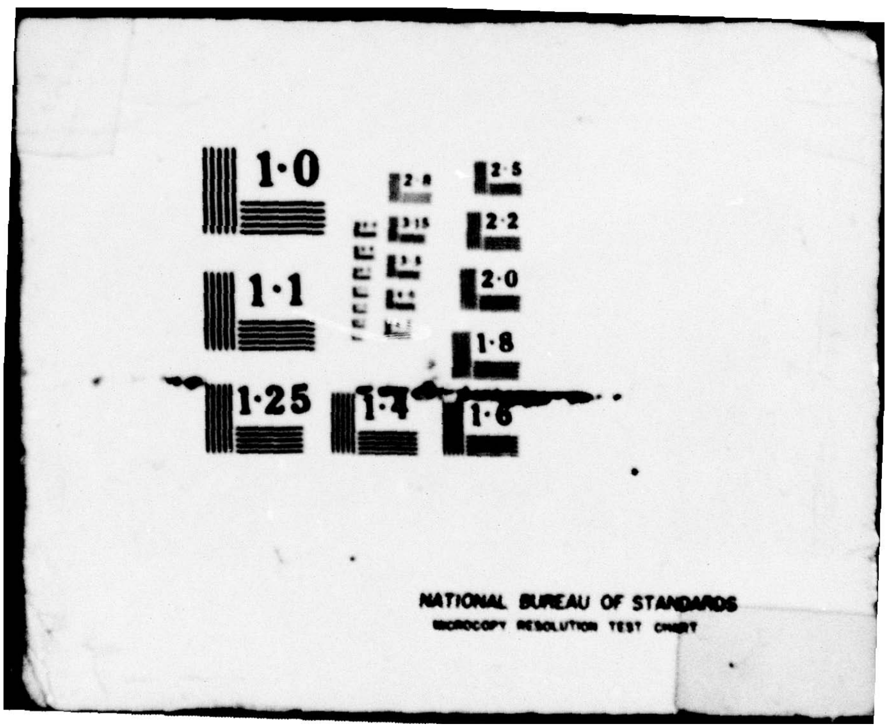
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USING LIGHT EMITTING DIODES (LED)
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By

Jan Tomaszewicz

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Using Light Emitting Diodes (LED) in Aircraft Analog Indicators

Jan Tomaszewicz

The possibilities of using an array of light emitting diodes in indicators of analog magnitude. Survey of operational diode systems and their controls and inspection of solution for LED analog indicator system elaborated at the Aircraft Institute.

In analog indicators build in support of LED diodes (Light Emitting Diodes--electroluminiscent diodes) the work of a single diode is handled like the action of a binary type element (i.e., lights or does not light) and analog-to-digital converters (A/D) used in the system effect conversion of an analog signal (e.g., voltage) to a digital binary code corresponding to this signal--most often BCD (Figure 1). The A/D converter, obviously, is not necessary if the input signal is given in digital form (for example, in digital computers, in a data transmission terminal, etc.).

Two operational LED systems for indicators are used: with a single luminous diode (Fig. 2a) and with a luminous diode series (Fig. 2b). Two types of indicators with LED diodes are known--with zero at the left side of the scale and with zero in the center of the scale. The version of the system with the single luminous diode and with zero in the center of the scale was made and used

in the radio semi-compass model developed at the Aircraft Institute to find a planewreck victim. The operating principle of this type of indicator is shown in Fig. 3a. Figure 3b presents the version of the LED indicator system with zero in the center of the scale and with a luminous system of diodes.

Light emitting diodes [redacted] used in analog indicators in comparison with conventional magnetoelectric indicators, indicate many very essential features:

-- limitlessness of long worktime;

-- very great resistance to vibration and mechanical strokes (lack of moving parts, fragile electrodes, filaments, etc.);

-- they operate in each position without loss of precision, and do not require zero calibration, periodic calibration;

-- large angle of view (typically about 150°)--practically eliminating error of parallax reading;

-- operation of LED diodes is possible both in conditions of full light and in its absence (without the necessity of additional lighting of the scale);

-- made in 3 different colors: red, green and yellow, which makes it possible to use them for various purposes (indication, bearing, alarm, etc.);

-- are completely compatible for TTL and MOS systems which checks that control systems are simple and do not require additional

supply sources;

-- can be connected in parallel, in series, in matrix form, as well as in a different way (arc, circle-shape, etc.);

-- the position of zero can be in the center of the scale as well as at its end--depending on need.

The use of LED diodes instead of magnetoelectric indicators in aeronautics is a decidedly less expensive solution since expensive mechanical indicators are replaced by [redacted] inexpensive elements almost completely accessible in the domestic market.

Control systems for LED indicators are built in support of TTL self-contained systems series SN54/74 by Texas Instruments or by their national equivalent series UCY64/74 manufactured by CEMI. The output current of the TTL series self-contained systems equally typical 16 mA is completely sufficient so that the control system insures full brightness of illumination of the LED diode. Special systems are built (e. g., decoder system 1 of 10 SN54/7445 by Texas Instruments--currently not having national equivalent) for operational diode systems requiring greater control currents.

A review is given below of control systems for a various number of LED diodes connected in series, in parallel, in the form of matrix systems.

PARALLEL SYSTEMS--SINGLE LUMINOUS ELEMENT

In a parallel system of operation single LED diodes or the matrix are connected by anodes (system with a common anode) or also by cathodes (system with a common cathode). Since the allowable output current of TTL systems is equal to 16 mA (and is specified for a low state in the output, that is, for Uwy = Uol, where Uol is the level of zero logic), only the version of system with the common anode can be used in this case. Then we connect LED diodes by anodes with themselves and through the resistor of current restriction we join to + 5 V of voltage supply. This is the most popular method of using LED diodes, not requiring additional (in relation to + 5 V supply of TTL systems) sources of supply voltage. An additional source of voltage is necessary, however, in the case where we connect 2 or more diodes in a series.

Control System of LED 16-diode by a 4-bit Binary Signal

Using the SN74154 (UCY74154) self-contained system permits control of up to a 16 diode LED by a 4-bit control system (Fig. 4). The work principle of the system is clarified by the following example: for the binary word HLHL (H signifies the level of lc [illegible], L is the level of zero logic) give[illegible] to the control inputs I_D, I_C, I_B, I_A of the decoder on the supposition that both gate inputs $I_{G1} = I_{G2} = 0$, only one output system SN74154 is in low state (i.e., $Q_{10} = L$), and the remaining ones are in state H. This means that only the diode connected to the output Q_{10} will light. The current flowing through the diode is determined

through the resistor of current restriction R, whose value we establish by the following:

$$R = (V_{CC} - V_F)/I$$

where V_{CC} is the supply voltage of the system (in this case $V_{CC} = +5$ V), V_F is the voltage drop in the conductive LED diode, I is the current flowing through the diode.

The characteristics of diodes defining the dependence $I = f(V_F)$ are defined in catalogs by the manufacturers.

Control System of 32-diode LED by a 5-bit Binary System

We get the operational system for 32 diodes from the system shown in Figure 4, adding an inverter (1/6 SN7404/UCY7404) and another decoder SN74154/UCY74154. Inputs controlling the decoders are connected in parallel, while the inverter controls the choice of one of two decoders (one of them is connected for diodes having numbers from 0-15, the other for diodes numbered 16-31; Fig. 5).

Control System of 64-diode LED by 6-bit Control Signal

Expansion of the analog scale system to 64 LED diodes requires using 1 decoder from 10 (SN7442/UCY7442) as an element controlling the operation of decoders SN74154/UCY74154 (Fig. 6). Decoder SN7442 operates in

a system of sequential selection of SN74154 decoders. We require in this case only one resistor of current restriction and at a given moment only one diode lights.

PARALLEL SYSTEM--ILLUMINATED SERIES

If we want the value of the input signal to be illuminated in the form of an illuminated diode series, it is necessary to have a modification of systems with a single luminous element. It depends on the addition of SN7407/UCY7407 systems joined as the total on the conductor (wire OR) to decoder outputs. There is an additional requirement that the binary decoder be a system with an open collector (e.g., SN74159, without domestic equivalent). In effect, not just one diode lights but also those whose binary weight is less or equal to the actual value of the input signal. This solution however, requires as many current restriction resistors as the analog scale contains of LED diodes (Fig. 7).

SERIES SYSTEM--ILLUMINATED SERIES

A series system with an illuminated series of diodes has the feature, in relation to a parallel system, that the current drawn from the supply source is direct and equals 10-20 mA (typical point of operation of LED diode). This fact makes the system particularly useful in the case when we require automatic control of brightness of illumination depending on external lighting. However, for this type of systems greater supply voltage is needed and corresponding TTL

control systems (open collector with enlarged output parameters, i.e., 80 mA/ 30 V; e.g., SN7445, SN74145, SN74141--without domestic equivalent). For example: for 10 LED diodes which draw a maximum 20 mA of current (catalog value), and the entire voltage drop is 16 V (for red diodes) and 27 V (for green and yellow) -- the use of this type of decoder is necessary (Fig. 8). For an input signal of 0-9 (in the decimal version) outputs 0, 1, 2, ... 9 will be sequentially joined to state L. This means that diodes 1, 1+2, 1+2+3, ... will be joined by the resistor R_v to the supply voltage +30 V. The criteria for selecting the R_v resistor are the following:

$$R_v = (V_{CC} - 10\,V_F)I_F$$

where: $V_{CC} = +30$ V, V_F is the conducting voltage of the LED diode (1.6 V), I_F is the LED diode current for $V_F = 1.6$ V (20 mA), $R_v = 680\ \Omega$.

Then the maximum current flowing through one diode:

$$I_{F\max} = (V_{CC} - V_F)/R_v \simeq 42 \text{ mA}$$

For the naked eye indicating the logarythmic dependence of impressions from the luminous intensity a change in the light intensity of the diodes depending on how many are lit is hardly perceptible. This disadvantage can be eliminated by using instead of the R_v resistor a current source. This solution, however, is more expensive and suggested for use in the case of green and yellow diodes where the luminous intensity of diodes in the current function through a non-flowing one

is considerably larger for red diodes.

MATRIX SYSTEMS--SINGLE ILLUMINATED ELEMENT

When using a larger number of diodes in indicators the use of matrix systems is considerably more advantageous than the systems mentioned above. It reaches considerable simplicity and economy of control systems in relation to the number of diodes. Typical solutions for illuminated matrix systems for 16 and 100 LED diodes are shown in Figures 9 and 10.

EXAMPLE OF COMPLETE REALIZED LED ANALOG INDICATOR WITH 13 ILLUMINATED ELEMENTS

At the Aircraft Institute a model was developed of an analog scale with zero in the center of the scale used for a radio semi-compass to search for a planewreck victim. The assembly has the following useful parameters:

-- zero in the center of the scale

-- system sensitivity no less than 1 mV/interval

-- number of bits in A/D converter--4

-- number of illuminated elements--13 (maximum 20).

The model of the system was made as a dual one for a solution with an imported magnetoelectric indicator left-right, which is very expensive and not easily accessible. A feature of the system (besides the economic side) is also

the possibility to regulate sensitivity in a very broad range--depending on the user's need. The system developed is composed of 2 fundamental blocks: a 4-bit analog-digital converter with a conversion cycle of about 20 ms. and a system of decoders controlling the operation of LED diodes.

A block diagram of the system is presented in Fig. 11. Figure 12 presents a schemat of the complete solution of the LED analog scale system.

The realized analog scale system was constructed almost entirely dependent on elements of domestic production. The exception is the operational amplifier LM101 AT fulfilling the role of the comparator, which national industry does not manufacture. The use of this amplifier, however, is necessary since it operates regularly at $\pm$10.5 V of supply voltage, with small import costs in relation to the cost of the magnetoelectric indicator. The cost of the entire unit is a great deal less than the cost of the magnetoelectric indicator for the same surface taken in the unit.

Considered also was the possibility of using the UAA 180 system (specially developed from the viewpoint of the building of analog scales) of the Siemens company, however, due to the considerable non-linearity of the system and the necessity for the far gone adaptation to our purposes this solution was dismissed (opinion supported on catalog discernments).

It is possible to use automation of illumination brightness of LED diodes depending on external lighting, if during flight testing, it appears necessary.

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2 Monsanto: Optoelectronics Catalog 1976
3 Siemens: Analog Integrated Circuits 1976/77.

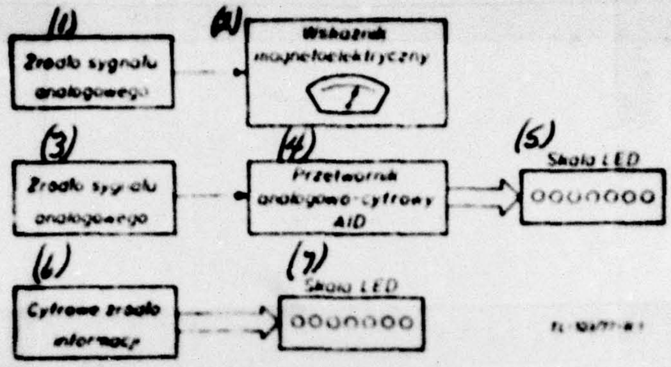

Fig. 1. Operating principles of analog scales.

Key: (1) Analog signal source; (2) Magnetoelectric indicator; (3) Analog signal source; (4) Analog-digital converter; (5) Scale; (6) Digital source of information; (7) Scale.

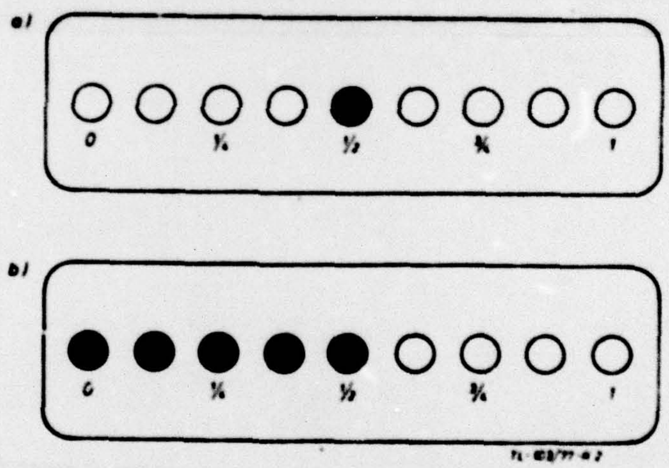

Fig. 2. LED Scale: a--with single luminous diode; b--with luminous series of diodes

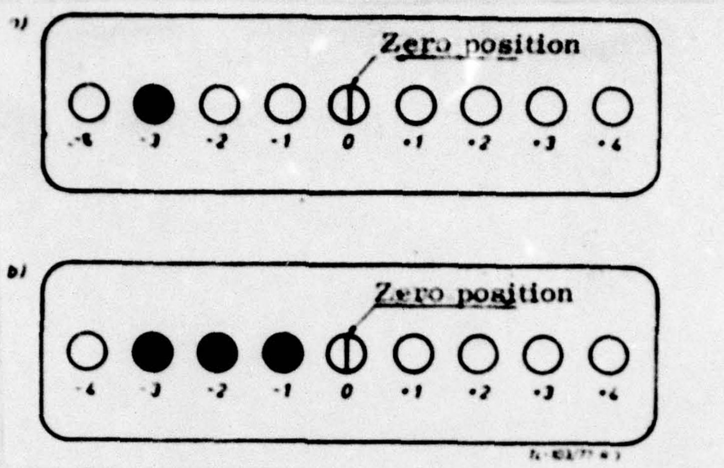

Fig. 3. LED Scale with zero in center: a) single luminous element; b)--luminous series.

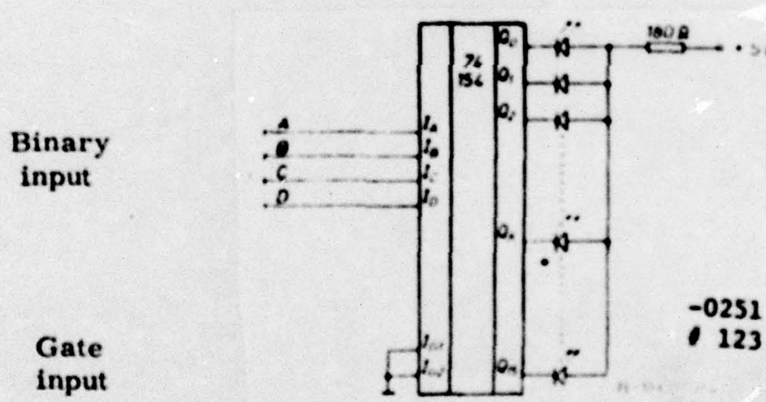

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Fig. 4. Parallel system--16 diode scale

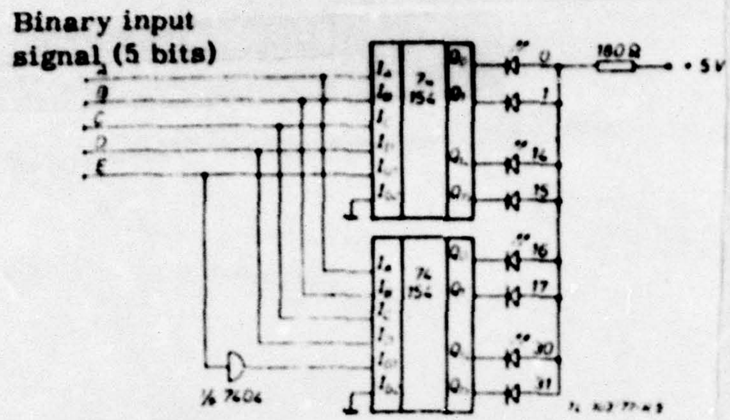

Fig.5. Parallel system 32 diode scale

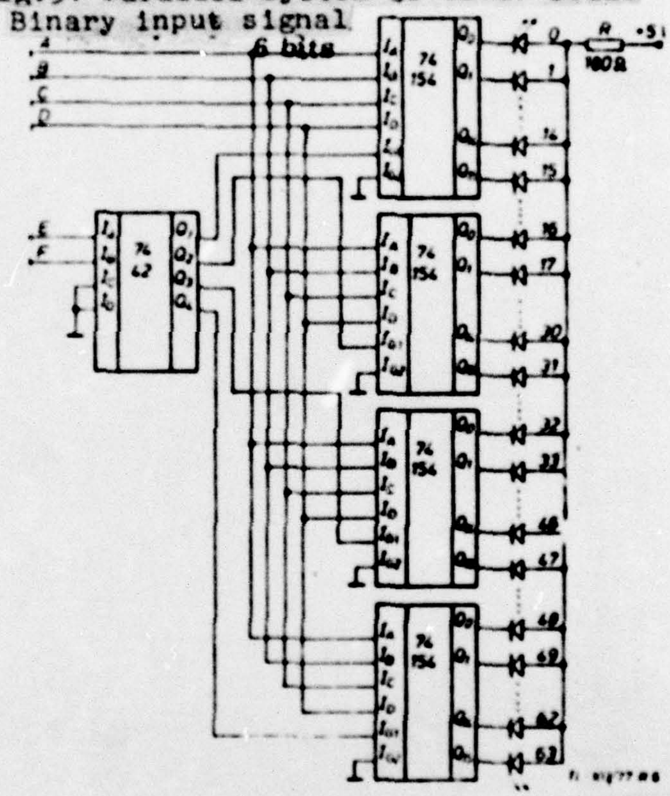

Fig. 6. Parallel system-64 diode scale

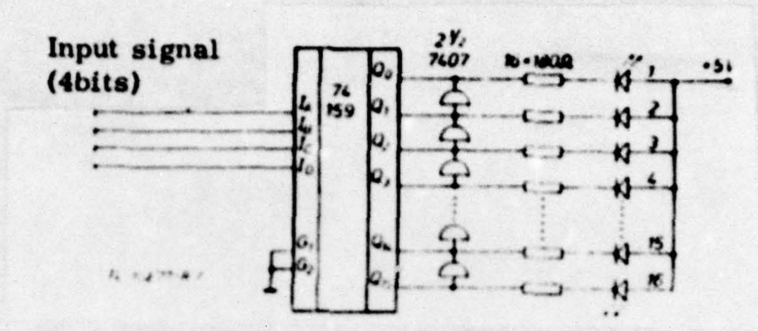

Fig. 7. Parallel system with luminous series of diodes.

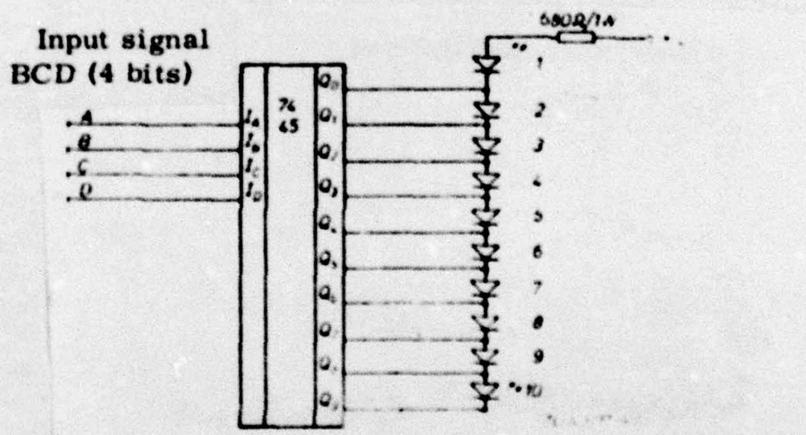

Fig. 8. Series system with luminous series of diodes.

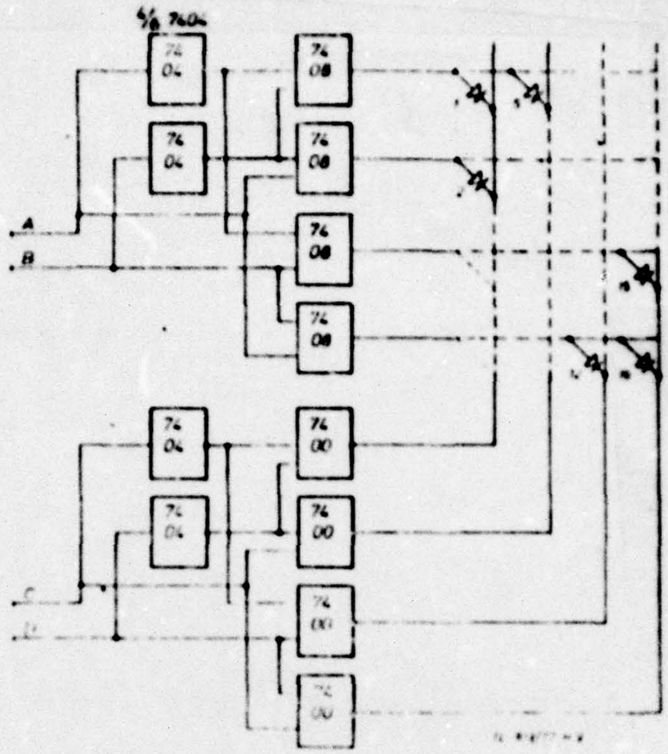

Fig. 9. Matrix, 16-diode system.

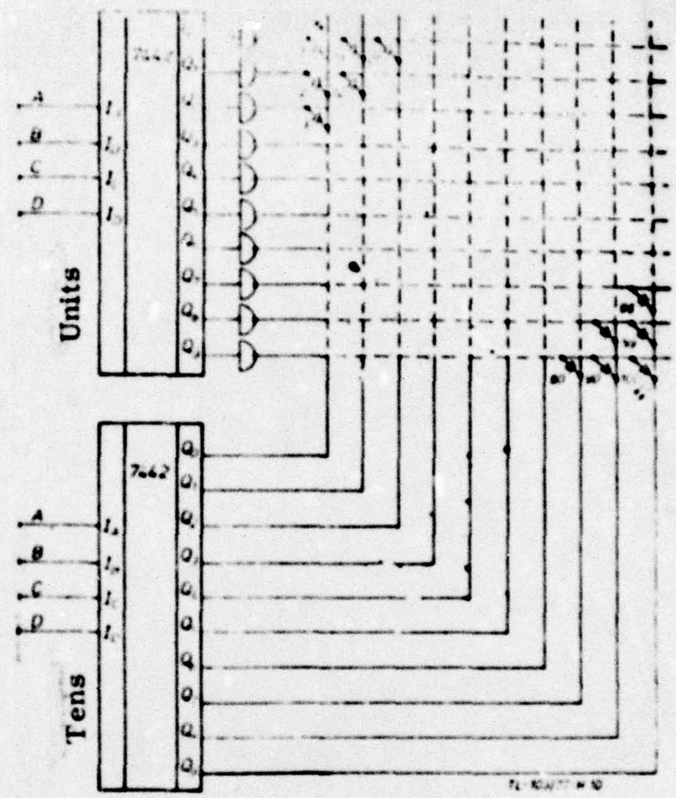

Fig. 10. Matrix, 100-diode system.

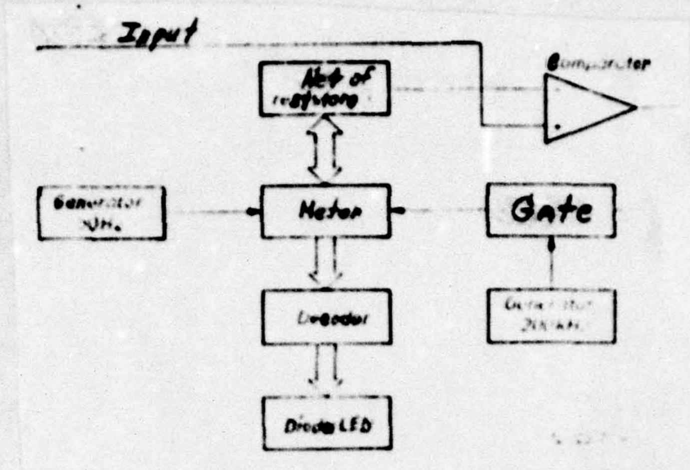

Fig. 11. Block scheme of realized A/D converter.

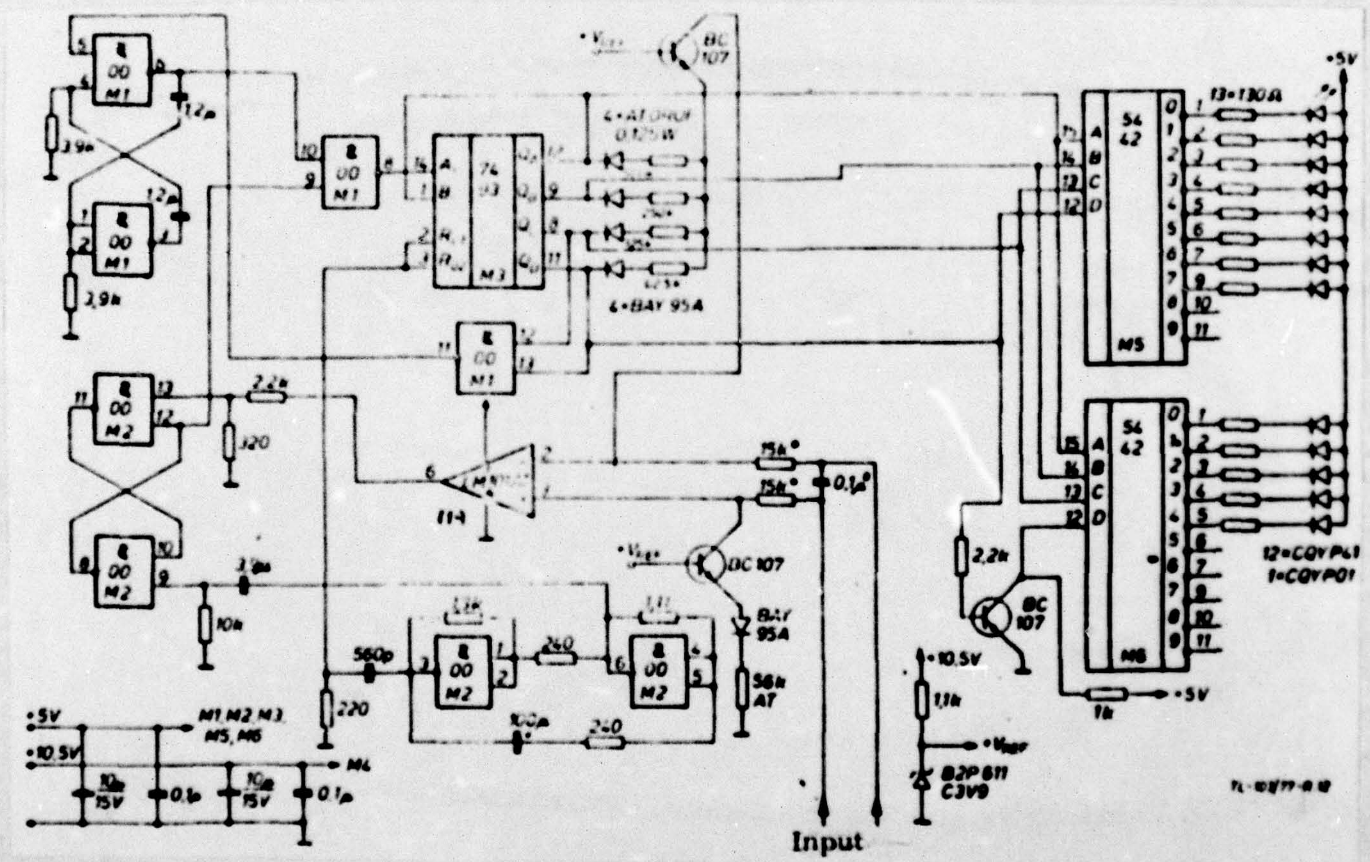

Fig. 12. Complete solution to LED scale of radio semi-compass to find planewreck victim.

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